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ll and Karl Huemmrich, Editors

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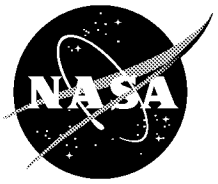

Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)

Forrest G. Hall and Karl Huemmrich, Editors

Volume 197

BOREAS TF-4 SSA-YJP Tower Flux, Meteorological, and Canopy Condition Data

Robert Striegl and Kimberly Wickland
U.S. Geological Survey, Denver

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

October 2000

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BOREAS TF-4 SSA-YJP Tower Flux, Meteorological, and Canopy Condition Data

Rob Striegl, Kimberly P. Wickland

Summary

The BOREAS TF-4 team collected energy, carbon dioxide, and water vapor flux data at the BOREAS SSA-YJP site during the growing season of 1994. In addition, meteorological data were collected both above and within the canopy. The data are available in tabular ASCII files.

Table of Contents

1. Data Set Overview

1.1 Data Set Identification

BOREAS TF-04 SSA-YJP Tower Flux, Meteorological, and Canopy Condition Data

1.2 Data Set Introduction

Measurements of CO_2 and latent and sensible heat flux were made both above and within the BOReal Ecosystem-Atmosphere Study (BOREAS) Southern Study Area (SSA) Young Jack Pine (YJP) canopy during a growing season. Combined with soil gas effluxes of CO_2 and CH_4, the data were used to determine daily and seasonal patterns in carbon fluxes, evapotranspiration, and environmental controls regulating the partitioning of available energy and net ecosystem productivity (NEP). Comparisons were made between young and mature jack pine stands in proximity to one another in terms of NEP and water use.

1.3 Objective/Purpose

The objectives of this study were to investigate carbon, water, and energy fluxes in boreal forests through an integrated approach involving flux estimates across the atmosphere-forest and soil-atmosphere boundaries. Eddy correlation measurements of CO_2, latent and sensible heat fluxes, and momentum were made above the SSA-YJP stand. Concentration profiles of CH_4, $^{12}CO_2$, and $^{13}CO_2$ were determined within the canopy during one Intensive Field Campaign (IFC). Soil-atmosphere flux studies employed soil depth vs. gas concentration measurements, flux chambers, and diffusion modeling to determine source and movement of CH_4, $^{12}CO_2$, and $^{13}CO_2$ in the air-soil-water continuum. The distribution and storage of carbon species in the soil profile were also determined. Long-term carbon accumulation was evaluated by ^{14}C decay of soil carbon. Net, incoming, and Photosynthetically Active Radiation (PAR); leaf photosynthesis; and certain soil parameters (heat flux, thermal profile) were also measured at the site.

1.4 Summary of Parameters and Variables

Types of Data Collected:

- Above-canopy fluxes: CO_2, latent heat, sensible heat
- Forest floor fluxes: CO_2, sensible heat, latent heat
- Radiation: Net, PAR, and shortwave
- Profiles: CO_2, air temperature, vapor pressure
- Tree: Tree bole temperatures
- Other Mean Variables:
- Above-canopy: Wind direction and speed, air temperature, vapor pressure
- Below-canopy: Wind speed, temperature, vapor pressure

1.5 Discussion

Flux data were collected from a 12-m tower in an 11- to 16-year-old jack pine stand. The trees were about 4 to 5 meters tall. Flux and meteorological data were collected from mid-May through mid-September 1994.

1.6 Related Data Sets

BOREAS TF-04 CO2 and CH4 Chamber Flux Data from the SSA
BOREAS TF-05 SSA-OJP Tower Flux, Meteorological, and Soil Temperature Data
BOREAS TF-10 NSA-YJP Tower Flux, Meteorological, and Porometry Data
BOREAS TF-11 SSA Fen Tower Flux, Meteorological, and Soil Temperature Data

2. Investigator(s)

2.1 Investigator(s) Name and Title

Dr. Dean Anderson
United States Geological Survey

Dr. Rob Striegl, Hydrologist
USGS

Dr. Kimberly Wickland, Hydrologist
USGS

2.2 Title of Investigation

Exchange of Trace Gases, Water, and Energy in Disturbed and Undisturbed Boreal Forests

2.3 Contact Information

Contact 1:
Dr. Rob Striegl
Hydrologist, USGS
P.O. Box 25046 MS 413
Denver, CO 80225
rstriegl@usgs.gov

Contact 2:
Dr. Kimberly P. Wickland
Hydrologist, USGS
P.O. Box 25046 MS 413
Denver, CO 80225

Contact 3:
K. Fred Huemmrich
University of Maryland
Code 923
NASA GSFC
Greenbelt, MD 20771
(301) 286-4862
(301) 286-0239 (fax)
Karl.Huemmrich@gsfc.nasa.gov

3. Theory of Measurements

The sonic anemometer/thermometer is designed to measure wind velocity components by transmitting and receiving sonic signals along fixed orthogonal directions. The microcomputer electronics then processes this information and calculates the wind speed in three axes. Since there are no moving parts to come into dynamic equilibrium with the air flow, the sonic anemometer/thermometer responds rapidly to wind velocity fluctuations. It responds linearly to wind velocity and is free from contamination from pressure, temperature, and relative humidity. The calibration of the sensor is established by its design parameters and therefore can be used as an absolute instrument. The probe array is designed to minimize flow distortion created by the supporting base and to permit a very wide unobstructed coverage of the vertical component.

4. Equipment

4.1 Sensor/Instrument Description

4.1.1 Collection Environment

Measurements were collected from mid-May through mid-September 1994 in an 11- to 16-year-old jack pine stand. Over that time period, temperature conditions went from slightly below freezing up to 29 °C.

4.1.2 Source/Platform

Instruments were mounted on a 12-m-tall Rohn tower.

4.1.3 Source/Platform Mission Objectives

The purpose of the tower was to suspend instruments to measure trace gas, energy fluxes, and meteorological variables above a young jack pine stand.

4.1.4 Key Variables

Sensible and latent heat fluxes were measured both above and below the tree canopies. CO_2 flux and concentration were measured above the canopy. Measurements of radiation included net radiation, PAR, and shortwave radiation. Meteorological measurements included wind speed and direction, friction velocity, air temperature, vapor pressure, air pressure, and rainfall. Under the canopy, data on air temperature, vapor pressure, and wind speed were collected. Bole temperature and leaf wetness data were collected. Within the canopy, air temperature, vapor pressure, and air pressure were measured.

4.1.5 Principles of Operation

Heat, water, and CO_2 fluxes were measured using eddy correlation techniques. Meteorological measurements were collected using standard instruments and methods.

4.1.6 Sensor/Instrument Measurement Geometry

The placement of instruments on the tower was at the following heights above the ground:

- Solar Radiation, LI-COR LI200S, at 12.9 m.
- PAR sensor, LI-COR LI190SZ, at 12.9 m.
- Air temperature and vapor pressure, Campbell Scientific, Inc., HMP35C, at 1.1, 9.1, and 12.2 m. Used an unaspirated, white plastic 12-plate Gill radiation shield, Campbell Scientific, Inc., model 41002.
- Wind speed and direction, R.M. Young 03001-5, at 1.1, 10.0, and 11.0 m.
- Net Radiation at 9.1 m.
- Sonic anemometer, both Applied Technologies, Inc. (ATI), and Campbell, at 1.1 and 9.1 m.
- LI-COR CO_2 sensor at 9.1 m.
- National Center for Atmospheric Research (NCAR)/Atmospheric Technology Division (ATD) CO_2 sensor at 1.1 m.

Bole temperatures were measured in two trees. In each tree, thermocouples were inserted into the north, east, south, and west sides of the bole, to approximately one half the radius of the trunk, at four heights. The first tree was 4.6 m tall; about average for the canopy. For that tree, the four heights were 0.58 m, 1.73 m, 2.79 m, and 3.68 m; the corresponding trunk diameters at those heights were 5.7 cm, 5.1 cm, 3.8 cm, and 2.9 cm. The second tree was about 3.6 m tall. The four heights were 0.46 m, 1.35 m, 2.24 m, and 2.74 m; the corresponding diameters were 3.3 cm, 2.9 cm, 2.2 cm, and 1.1 cm.

Within-canopy air temperature and vapor pressure were measured with the Campbell Scientific, Inc., HMP35C, at 1.2 m above ground level. An unaspirated, white plastic 12-plate Gill radiation shield (Campbell Scientific, Inc., model 41002) was also used. Within-canopy atmospheric pressure was measured using the Setra 270, at 1.7 m

Leaf wetness sensors (Campbell Scientific, Inc., 237) were placed at heights of 1.6 m and 1.4 m. The first leaf wetness sensor was deployed in a small opening in the trees, sloping about 40° to the northeast. The second sensor was placed about 10 cm from a tree trunk, sloping about 40° to the west.

Rainfall was measured using a tipping bucket rain gauge (Weathertronics 6010) in a clearing approximately 10 m in diameter at 0.6 m height. The 45°-angle cone above the rain gauge may have been slightly encroached upon by treetops as the average tree height was about 4.6 m.

4.1.7 Manufacturer of Sensor/Instrument

Sonic anemometer:
Applied Technologies, Inc.
1120 Delaware Ave.
Longmont, C) 80501
(303) 684-8722
(303) 684-8773 (fax)
sales@apptech.com

Sonic anemometer, CO_2 sensor:
NCAR/ATD
P.O. Box 3000, 1850 Table Mesa Drive
Boulder, CO 80307 USA
(303) 497-8833
(303) 497-8770 (fax)
atd_info@atd.ucar.edu

Sonic anemometer, temperature/humidity sensor HMP35C, Campbell 21X data logger, Gill radiation shield model 41002, leaf wetness sensor model 237, AM416 multiplexer, AM-ENCT insulating enclosure, CO_2 sensor:
Campbell Scientific, Inc.
815 West 1800 North
Logan, UT 84321-1784
(435) 753-2342
(435) 750-9540 (fax)
info@campbellsci.com

LI-COR LI200S, LI190SZN, CO_2 sensor:
LI-COR Environmental Division
4421 Superior Street
Lincoln, NE 68504
(800) 447-3576
(402) 467-3576
(402) 467-2819 (fax)

Wind direction and speed 03001-5:
R.M. Young Company
2801 Aero Park Drive
Traverse City, MI 49686
(616) 946-3980
(616) 946-4772 (fax)
met.sales@youngusa.com

Rain Gauge Weathertronics 6010:
WeatherMeasure Weathertronics
Qualimetrics, Inc.
1165 National Drive
Sacramento, CA 95834
(916) 928-1000
(916) 928-1165 (fax)

4.2 Calibration

None.

4.2.1 Specifications

Two problems remain, to one degree or another, with all existing sonic anemometers: distortion of the measured flow field by the anemometer array itself and reliable detection of the transmitted sound pulses by the anemometer electronics over a wide range of environmental conditions.

4.2.1.1 Tolerance

None.

4.2.2 Frequency of Calibration

None.

4.2.3 Other Calibration Information

None.

5. Data Acquisition Methods

The tower meteorological data were collected using a Campbell 21X data logger. All sensors except the rain gauge were located on the flux tower. Sensors were scanned every 5 s, and half-hour averages were recorded. Vapor pressure was calculated as the product of saturated vapor pressure at air temperature and relative humidity (100% = 1). Saturated vapor pressure was calculated using the Lowe (1977) equation. The tipping bucket rain gauge (one tip = 0.25 mm of rain) was deployed in a clearing approximately 10 m in diameter. The 45° cone above the rain gauge may have been slightly encroached upon by treetops.

The canopy meteorological data were collected using a Campbell 21X data logger. Sensors were scanned every 60 s, and half-hour averages were recorded. Vapor pressure was calculated as described above. The reported air pressure was atmospheric (i.e., not corrected to sea level) rather than barometric pressure. Air pressure was recorded to the nearest mb until day of year 215 at 2000 Greenwich Mean Time (GMT), and to the nearest hundredth of a mb thereafter. The leaf wetness sensors were artificial leaf electrical resistance types, with interlacing gold plated copper fingers. Water droplets that bridge between fingers lower the resistance. These sensors were not painted or coated. The manufacturer suggests that the transition from "wet" to "dry" for an uncoated sensor occurs between 50 and 200 kohms. The first leaf wetness sensor was deployed in a small opening in the trees, sloping about 40° to the northeast. The second leaf wetness sensor was deployed about 10 cm from a tree trunk, sloping about 40° to the west.

Tree bole temperatures were collected using a Campbell 21X data logger. Copper-constantan thermocouples were glued into tree boles to make all of these temperature measurements. A Campbell AM416 multiplexer was used to route the thermocouples to the logger. An extra thermocouple reference junction was glued to the AM416 surface, and the AM416 was enclosed in a Campbell AM-ENCT insulating enclosure to minimize temperature gradients in the AM416. Sensors were scanned every 5 s during the last minute of each half-hour, and averages of the 13 readings were recorded.

Two trees were chosen to instrument. The first was 4.6 m tall, about average for the canopy. Thermocouples were inserted into the north, east, south, and west sides, to approximately one half the radius of the trunk, at four heights. The four heights were 0.58 m, 1.73 m, 2.79 m, and 3.68 m; the corresponding trunk diameters at those heights were 5.7 cm, 5.1 cm, 3.8 cm, and 2.9 cm. The second tree was about 3.6 m tall. The four heights were 0.46 m, 1.35 m, 2.24 m, and 2.74 m; the corresponding diameters were 3.3 cm, 2.9 cm, 2.2 cm, and 1.1 cm. In the reported data set, the 16 temperatures from each tree were averaged together for each half-hour, and the mean temperature was reported.

6. Observations

6.1 Data Notes

Measurements began during IFC-1 and ended a day after IFC-3. Equipment operated almost continuously. Notable were the lack of CO_2 data following a lightning strike and a malfunction of the CO_2 sensor 16-Jun to 20-Jun and 10-Jul to 19-Jul-1994. CO_2 profile instruments were not operational until IFC-2. Forest floor sensible and latent heat flux record had numerous lapses due to equipment problems. Considering all measurements, IFC-3 had the most complete record.

6.2 Field Notes

None.

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

All data were collected at the BOREAS SSA-YJP site. North American Datum of 1983 (NAD83) coordinates for the site are latitude 53.87581° N, longitude 104.64529° W, and elevation of 533.54 m.

7.1.2 Spatial Coverage Map

Not applicable.

7.1.3 Spatial Resolution

Data collected from flux towers are often thought of as point data. However, particularly in terms of the eddy flux data, they actually represent an integrated upwind source region. The size of the region being sampled is related to factors such as the height of the tower, the roughness of the canopy, and the wind speed. An estimate of the upwind distance for the YJP site is 20 to 400 m upwind.

7.1.4 Projection

Not applicable.

7.1.5 Grid Description

Not applicable.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage

Meteorological data were collected from 02- to 06-Sep-1993, and during 1994 from 15-May to 20-Sep. Within-canopy meteorological data were collected continuously during 1994 from 03-Jun to 20-Sep, except for a gap from 04- to 07-Aug. Tree bole temperature data were collected continuously from 10-Jun to 20-Sep-1994, except for a gap from 14-Jun to 21-Jun. Flux data were collected from 26-May to 20-Sep-1994. There were gaps in CO_2 data following a lightning strike and a malfunction of the CO_2 sensor 16-Jun to 20-Jun and 10-Jul to 19-Jul-1994. CO_2 profile instruments were not operational until IFC-2. The forest floor sensible and latent heat flux record had numerous lapses due to equipment problems.

7.2.2 Temporal Coverage Map

None.

7.2.3 Temporal Resolution

Meteorological and radiation sensors were scanned every 5 s, and half-hour averages were recorded. Within-canopy meteorology data sensors were scanned every 60 s, and half-hour averages were recorded. Tree bole temperature sensors were scanned every 5 s during the last minute of each half-hour, and averages of the 13 readings were recorded.

7.3 Data Characteristics

7.3.1 Parameter/Variable

The parameters contained in the data files on the CD-ROM are:

Column Name
SITE_NAME
SUB_SITE
DATE_OBS
TIME_OBS
SENSIBLE_HEAT_FLUX_ABV_CNPY
CAM_SENS_HEAT_FLUX_ABV_CNPY
LATENT_HEAT_FLUX_ABV_CNPY
CAM_LATENT_HEAT_FLUX_ABV_CNPY
NET_RAD_ABV_CNPY
CO2_FLUX_ABV_CNPY
LIC_CO2_FLUX_ABV_CNPY
CO2_FLUX_PROFILE
CO2_CONC_ABV_CNPY
WIND_SPEED_ABV_CNPY
WIND_SPEED_ABV_CNPY_2
MAGN_WINDSPEED_VECTOR_ABV_CNPY
WIND_DIR_ABV_CNPY
MEAN_WIND_DIR_ABV_CNPY
SDEV_WIND_DIR_ABV_CNPY
WIND_SPEED_110CM
FRICTION_VEL_ABV_CNPY
STABILITY_INDEX_ABV_CNPY
DOWN_PAR_ABV_CNPY
DOWN_PPFD_ABV_CNPY
AIR_TEMP_ABV_CNPY
AIR_TEMP_ABV_CNPY_2
AIR_TEMP_110CM
DOWN_SOLAR_RAD_ABV_CNPY
DOWN_SOLAR_RAD_ABV_CNPY_2
VAPOR_PRESS_ABV_CNPY
VAPOR_PRESS_ABV_CNPY_2
VAPOR_PRESS_110CM
VAPOR_PRESS_DEFICIT_ABV_CNPY
VAPOR_PRESS_DEFICIT_110CM
SURF_PRESS
SENSIBLE_HEAT_FLUX_BELOW_CNPY
LATENT_HEAT_FLUX_BELOW_CNPY
MEAN_BOLE_TEMP_1
MEAN_BOLE_TEMP_2
CNPY_AIR_TEMP_120CM
CNPY_VAPOR_PRESS_120CM

CNPY_SURF_PRESS_170CM
LEAF_WET_160CM
LEAF_WET_140CM
RAINFALL
CRTFCN_CODE
REVISION_DATE

7.3.2 Variable Description/Definition

The descriptions of the parameters contained in the data files on the CD-ROM are:

Column Name	Description
SITE_NAME	The identifier assigned to the site by BOREAS, in the format SSS-TTT-CCCCC, where SSS identifies the portion of the study area: NSA, SSA, REG, TRN, and TTT identifies the cover type for the site, 999 if unknown, and CCCCC is the identifier for site, exactly what it means will vary with site type.
SUB_SITE	The identifier assigned to the sub-site by BOREAS in the format GGGGG-IIIII, where GGGGG is the group associated with the sub-site instrument, e.g. HYD06 or STAFF, and IIIII is the identifier for sub-site, often this will refer to an instrument.
DATE_OBS	The date on which the data were collected.
TIME_OBS	The Greenwich Mean Time (GMT) of the start of the data collection.
SENSIBLE_HEAT_FLUX_ABV_CNPY	The sensible heat flux measured above the canopy
CAM_SENS_HEAT_FLUX_ABV_CNPY	The sensible heat flux measured above the canopy using the Campbell Scientific sensor.
LATENT_HEAT_FLUX_ABV_CNPY	The latent heat flux measured above the canopy.
CAM_LATENT_HEAT_FLUX_ABV_CNPY	The latent heat flux measured above the canopy using the Campbell Scientific sensor.
NET_RAD_ABV_CNPY	The net radiation measured above the canopy.
CO2_FLUX_ABV_CNPY	The carbon dioxide flux measured above the canopy
LIC_CO2_FLUX_ABV_CNPY	The carbon dioxide flux measured above the canopy using the LiCor instrument.
CO2_FLUX_PROFILE	The CO2 flux profile.
CO2_CONC_ABV_CNPY	The carbon dioxide concentration measured above the canopy.
WIND_SPEED_ABV_CNPY	The wind speed measured above the canopy.
WIND_SPEED_ABV_CNPY_2	The mean wind speed measured above the canopy over a 30 minute period.
MAGN_WINDSPEED_VECTOR_ABV_CNPY	The magnitude of the winspeed vector measured above the canopy.
WIND_DIR_ABV_CNPY	The direction from which the wind is blowing (in creasing in a clockwise direction from the North) and measured above the canopy.
MEAN_WIND_DIR_ABV_CNPY	The mean wind direction measured above the canopy over a 30 minute period.
SDEV_WIND_DIR_ABV_CNPY	The standard deviation of the wind direction measured above the canopy over a 30 minute period.

WIND_SPEED_110CM	The wind speed measured at 1.1 meters above ground level.
FRICTION_VEL_ABV_CNPY	The friction velocity above the canopy.
STABILITY_INDEX_ABV_CNPY	The z/L stability index measured above the canopy
DOWN_PAR_ABV_CNPY	The incoming photosynthetically active radiation measured above the canopy.
DOWN_PPFD_ABV_CNPY	The downward (incoming) photosynthetic photon flux density measured above the canopy.
AIR_TEMP_ABV_CNPY	The air temperature measured above the canopy.
AIR_TEMP_ABV_CNPY_2	The mean air temperature measured above the canopy over a 30 minute period.
AIR_TEMP_110CM	The air temperature measured at 1.1 meters above ground level.
DOWN_SOLAR_RAD_ABV_CNPY	The downward (incoming) solar radiation measured above the canopy.
DOWN_SOLAR_RAD_ABV_CNPY_2	The downward (incoming) solar radiation measured above the canopy.
VAPOR_PRESS_ABV_CNPY	The vapor pressure measured above the canopy.
VAPOR_PRESS_ABV_CNPY_2	The mean vapor pressure measured above the canopy over a 30 minute period.
VAPOR_PRESS_110CM	The vapor pressure measured at 1.1 meters above ground level.
VAPOR_PRESS_DEFICIT_ABV_CNPY	The vapor pressure deficit measured above the canopy.
VAPOR_PRESS_DEFICIT_110CM	The vapor pressure deficit measured at 1.1 meters above ground level.
SURF_PRESS	The atmospheric pressure measured at the station
SENSIBLE_HEAT_FLUX_BELOW_CNPY	The sensible heat flux measured below the canopy
LATENT_HEAT_FLUX_BELOW_CNPY	The latent heat flux measured below the canopy.
MEAN_BOLE_TEMP_1	The average bole temperature for tree 1.
MEAN_BOLE_TEMP_2	The average bole temperature for tree 2.
CNPY_AIR_TEMP_120CM	The air temperature measured within the canopy at a height of 1.2 meters.
CNPY_VAPOR_PRESS_120CM	The vapor pressure measured within the canopy at a height of 1.2 meters.
CNPY_SURF_PRESS_170CM	The atmospheric pressure measured within the canopy at a height of 1.7 meters above ground level.
LEAF_WET_160CM	The leaf wetness measured by an artificial leaf electrical resistance sensor. The sensor was placed in an opening in the trees at a height of 1.6 meters.
LEAF_WET_140CM	The leaf wetness measured by an artificial leaf electrical resistance sensor. The sensor was placed 10 cm from a tree trunk at a height of 1.4 meters.
RAINFALL	The amount of rainfall measured above the canopy in the 30 minute period following the given time
CRTFCN_CODE	The BOREAS certification level of the data. Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI but questionable).
REVISION_DATE	The most recent date when the information in the referenced data base table record was revised.

7.3.3 Unit of Measurement

The measurement units for the parameters contained in the data files on the CD-ROM are:

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
DATE_OBS	[DD-MON-YY]
TIME_OBS	[HHMM GMT]
SENSIBLE_HEAT_FLUX_ABV_CNPY	[Watts][meter^-2]
CAM_SENS_HEAT_FLUX_ABV_CNPY	[Watts][meter^-2]
LATENT_HEAT_FLUX_ABV_CNPY	[Watts][meter^-2]
CAM_LATENT_HEAT_FLUX_ABV_CNPY	[Watts][meter^-2]
NET_RAD_ABV_CNPY	[Watts][meter^-2]
CO2_FLUX_ABV_CNPY	[micromoles][meter^-2][second^-1]
LIC_CO2_FLUX_ABV_CNPY	[micromoles][meter^-2][second^-1]
CO2_FLUX_PROFILE	[micromoles][meter^-2][second]
CO2_CONC_ABV_CNPY	[parts per million]
WIND_SPEED_ABV_CNPY	[meters][second^-1]
WIND_SPEED_ABV_CNPY_2	[meters][second^-1]
MAGN_WINDSPEED_VECTOR_ABV_CNPY	[meters][second^-1]
WIND_DIR_ABV_CNPY	[degrees]
MEAN_WIND_DIR_ABV_CNPY	[degrees from north]
SDEV_WIND_DIR_ABV_CNPY	[degrees from north]
WIND_SPEED_110CM	[meters][second^-1]
FRICTION_VEL_ABV_CNPY	[meters][seconds^-1]
STABILITY_INDEX_ABV_CNPY	[unitless]
DOWN_PAR_ABV_CNPY	[watts][meter^-2]
DOWN_PPFD_ABV_CNPY	[micromoles][meter^-2][second^-1]
AIR_TEMP_ABV_CNPY	[degrees Celsius]
AIR_TEMP_ABV_CNPY_2	[degrees Celsius]
AIR_TEMP_110CM	[degrees Celsius]
DOWN_SOLAR_RAD_ABV_CNPY	[Watts][meter^-2]
DOWN_SOLAR_RAD_ABV_CNPY_2	[Watts][meter^-2]
VAPOR_PRESS_ABV_CNPY	[kiloPascals]
VAPOR_PRESS_ABV_CNPY_2	[kiloPascals]
VAPOR_PRESS_110CM	[kiloPascals]
VAPOR_PRESS_DEFICIT_ABV_CNPY	[kiloPascals]
VAPOR_PRESS_DEFICIT_110CM	[kiloPascals]
SURF_PRESS	[kiloPascals]
SENSIBLE_HEAT_FLUX_BELOW_CNPY	[Watts][meter^-2]
LATENT_HEAT_FLUX_BELOW_CNPY	[Watts][meter^-2]
MEAN_BOLE_TEMP_1	[degrees Celsius]
MEAN_BOLE_TEMP_2	[degrees Celsius]
CNPY_AIR_TEMP_120CM	[degrees Celsius]
CNPY_VAPOR_PRESS_120CM	[kiloPascals]
CNPY_SURF_PRESS_170CM	[kiloPascals]
LEAF_WET_160CM	[kilo ohms]
LEAF_WET_140CM	[kilo ohms]
RAINFALL	[millimeters]
CRTFCN_CODE	[none]
REVISION_DATE	[DD-MON-YY]

7.3.4 Data Source

The source of the parameter values contained in the data files on the CD-ROM are:

Column Name	Data Source
SITE_NAME	[Assigned by BORIS.]
SUB_SITE	[Assigned by BORIS.]
DATE_OBS	[Supplied by Investigator.]
TIME_OBS	[Supplied by Investigator.]
SENSIBLE_HEAT_FLUX_ABV_CNPY	[ATI sonic anemometer]
CAM_SENS_HEAT_FLUX_ABV_CNPY	[Campbell sonic anemometer]
LATENT_HEAT_FLUX_ABV_CNPY	[ATI sonic anemometer]
CAM_LATENT_HEAT_FLUX_ABV_CNPY	[Campbell sonic anemometer]
NET_RAD_ABV_CNPY	[net radiometer]
CO2_FLUX_ABV_CNPY	[ATD CO2 sensor]
LIC_CO2_FLUX_ABV_CNPY	[LiCor CO2 sensor]
CO2_FLUX_PROFILE	[CO2 sensor]
CO2_CONC_ABV_CNPY	[CO2 sensor]
WIND_SPEED_ABV_CNPY	[anemometer]
WIND_SPEED_ABV_CNPY_2	[anemometer]
MAGN_WINDSPEED_VECTOR_ABV_CNPY	[anemometer]
WIND_DIR_ABV_CNPY	[windvane]
MEAN_WIND_DIR_ABV_CNPY	[windvane]
SDEV_WIND_DIR_ABV_CNPY	[windvane]
WIND_SPEED_110CM	[anemometer]
FRICTION_VEL_ABV_CNPY	[sonic anemometer]
STABILITY_INDEX_ABV_CNPY	[Supplied by Investigator.]
DOWN_PAR_ABV_CNPY	[quantum sensor]
DOWN_PPFD_ABV_CNPY	[quantum sensor]
AIR_TEMP_ABV_CNPY	[psychrometer]
AIR_TEMP_ABV_CNPY_2	[psychrometer]
AIR_TEMP_110CM	[psychrometer]
DOWN_SOLAR_RAD_ABV_CNPY	[solarimeter]
DOWN_SOLAR_RAD_ABV_CNPY_2	[solarimeter]
VAPOR_PRESS_ABV_CNPY	[psychrometer]
VAPOR_PRESS_ABV_CNPY_2	[psychrometer]
VAPOR_PRESS_110CM	[psychrometer]
VAPOR_PRESS_DEFICIT_ABV_CNPY	[psychrometer]
VAPOR_PRESS_DEFICIT_110CM	[psychrometer]
SURF_PRESS	[barometer]
SENSIBLE_HEAT_FLUX_BELOW_CNPY	[ATI sonic anemometer]
LATENT_HEAT_FLUX_BELOW_CNPY	[ATI sonic anemometer]
MEAN_BOLE_TEMP_1	[thermocouple]
MEAN_BOLE_TEMP_2	[thermocouple]
CNPY_AIR_TEMP_120CM	[psychrometer]
CNPY_VAPOR_PRESS_120CM	[psychrometer]
CNPY_SURF_PRESS_170CM	[barometer]
LEAF_WET_160CM	[wetness sensor]
LEAF_WET_140CM	[wetness sensor]
RAINFALL	[tipping bucket rain gauge]
CRTFCN_CODE	[Assigned by BORIS.]
REVISION_DATE	[Assigned by BORIS.]

7.3.5 Data Range

The following table gives information about the parameter values found in the data files on the CD-ROM.

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SITE_NAME	SSA-YJP-FLXTR	SSA-YJP-FLXTR	None	None	None	None
SUB_SITE	9TF04-FLX01	9TF04-FLX01	None	None	None	None
DATE_OBS	02-SEP-93	20-SEP-94	None	None	None	None
TIME_OBS	0	2330	None	None	None	None
SENSIBLE_HEAT_FLUX_ABV_CNPY	-83.1	9999	None	None	None	Blank
CAM_SENS_HEAT_FLUX_ABV_CNPY	-97.3	512.2	-999	None	None	Blank
LATENT_HEAT_FLUX_ABV_CNPY	-19.9	481.3	-999	None	None	Blank
CAM_LATENT_HEAT_FLUX_ABV_CNPY	-116.5	454.1	-999	None	None	Blank
NET_RAD_ABV_CNPY	-78	689	-999	None	None	Blank
CO2_FLUX_ABV_CNPY	-5.88	10.88	-999	None	None	Blank
LIC_CO2_FLUX_ABV_CNPY	-15.2	14.67	-999	None	None	Blank
CO2_FLUX_PROFILE	-18.1	19.59	-999	None	None	Blank
CO2_CONC_ABV_CNPY	290	447.5	-999	None	None	Blank
WIND_SPEED_ABV_CNPY	0	8.13	-999	None	None	Blank
WIND_SPEED_ABV_CNPY_2	.2	8.13	None	None	None	Blank
MAGN_WINDSPEED_VECTOR_ABV_CNPY	.01	7.69	None	None	None	Blank
WIND_DIR_ABV_CNPY	0	360	None	None	None	Blank
MEAN_WIND_DIR_ABV_CNPY	0	359.9	None	None	None	Blank
SDEV_WIND_DIR_ABV_CNPY	0	79.9	None	None	None	Blank
WIND_SPEED_110CM	0	1.89	-999	None	None	Blank
FRICTION_VEL_ABV_CNPY	0	6.11	-999	None	None	Blank
STABILITY_INDEX_ABV_CNPY	-13.5	60.52	-999	None	None	Blank
DOWN_PAR_ABV_CNPY	-1	1850	None	None	None	Blank
DOWN_PPFD_ABV_CNPY	-.6	1917	None	None	None	Blank
AIR_TEMP_ABV_CNPY	-.56	29.82	None	None	None	Blank
AIR_TEMP_ABV_CNPY_2	-.56	29.82	None	None	None	Blank
AIR_TEMP_110CM	-4.04	32.65	-999	None	None	Blank
DOWN_SOLAR_RAD_ABV_CNPY	-1	939	-999	None	None	Blank
DOWN_SOLAR_RAD_ABV_CNPY_2	-1	982	None	None	None	Blank
VAPOR_PRESS_ABV_CNPY	.493	2.201	None	None	None	Blank
VAPOR_PRESS_ABV_CNPY_2	.48	2.19	None	None	None	Blank
VAPOR_PRESS_110CM	.46	2.522	-999	None	None	Blank
VAPOR_PRESS_DEFICIT_	0	3.129	-999	None	None	Blank

ABV_CNPY						
VAPOR_PRESS_DEFICIT_ 110CM	-.099	3.798	-999	None	None	Blank
SURF_PRESS	93.2	999	None	None	None	Blank
SENSIBLE_HEAT_FLUX_ BELOW_CNPY	-32.3	453.3	-999	None	None	Blank
LATENT_HEAT_FLUX_ BELOW_CNPY	-85.7	330	-999	None	None	Blank
MEAN_BOLE_TEMP_1	-1.78	35.02	None	None	None	Blank
MEAN_BOLE_TEMP_2	-2.93	36.18	None	None	None	Blank
CNPY_AIR_TEMP_120CM	-4.04	32.65	None	None	None	Blank
CNPY_VAPOR_PRESS_ 120CM	.443	2.519	None	None	None	Blank
CNPY_SURF_PRESS_ 170CM	93.2	96.912	None	None	None	Blank
LEAF_WET_160CM	2.6	6812	-999	None	None	Blank
LEAF_WET_140CM	2	6859	-999	None	None	Blank
RAINFALL	0	12.75	None	None	None	Blank
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	27-APR-99	27-APR-99	None	None	None	None

Minimum Data Value -- The minimum value found in the column.
Maximum Data Value -- The maximum value found in the column.
Missng Data Value -- The value that indicates missing data. This is used to indicate that an attempt was made to determine the parameter value, but the attempt was unsuccessful.
Unrel Data Value -- The value that indicates unreliable data. This is used to indicate an attempt was made to determine the parameter value, but the value was deemed to be unreliable by the analysis personnel.
Below Detect Limit -- The value that indicates parameter values below the instruments detection limits. This is used to indicate that an attempt was made to determine the parameter value, but the analysis personnel determined that the parameter value was below the detection limit of the instrumentation.
Data Not Cllctd -- This value indicates that no attempt was made to determine the parameter value. This usually indicates that BORIS combined several similar but not identical data sets into the same data base table but this particular science team did not measure that parameter.

Blank -- Indicates that blank spaces are used to denote that type of value.
N/A -- Indicates that the value is not applicable to the respective column.
None -- Indicates that no values of that sort were found in the column.

7.4 Sample Data Record

The following are wrapped versions of data record from a sample data file on the CD-ROM.

```
SITE_NAME,SUB_SITE,DATE_OBS,TIME_OBS,SENSIBLE_HEAT_FLUX_ABV_CNPY,
CAM_SENS_HEAT_FLUX_ABV_CNPY,LATENT_HEAT_FLUX_ABV_CNPY,
CAM_LATENT_HEAT_FLUX_ABV_CNPY,NET_RAD_ABV_CNPY,CO2_FLUX_ABV_CNPY,
LIC_CO2_FLUX_ABV_CNPY,CO2_FLUX_PROFILE,CO2_CONC_ABV_CNPY,WIND_SPEED_ABV_CNPY,
WIND_SPEED_ABV_CNPY_2,MAGN_WINDSPEED_VECTOR_ABV_CNPY,WIND_DIR_ABV_CNPY,
MEAN_WIND_DIR_ABV_CNPY,SDEV_WIND_DIR_ABV_CNPY,WIND_SPEED_110CM,
FRICTION_VEL_ABV_CNPY,STABILITY_INDEX_ABV_CNPY,DOWN_PAR_ABV_CNPY,
DOWN_PPFD_ABV_CNPY,AIR_TEMP_ABV_CNPY,AIR_TEMP_ABV_CNPY_2,AIR_TEMP_110CM,
DOWN_SOLAR_RAD_ABV_CNPY,DOWN_SOLAR_RAD_ABV_CNPY_2,VAPOR_PRESS_ABV_CNPY,
VAPOR_PRESS_ABV_CNPY_2,VAPOR_PRESS_110CM,VAPOR_PRESS_DEFICIT_ABV_CNPY,
VAPOR_PRESS_DEFICIT_110CM,SURF_PRESS,SENSIBLE_HEAT_FLUX_BELOW_CNPY,
LATENT_HEAT_FLUX_BELOW_CNPY,MEAN_BOLE_TEMP_1,MEAN_BOLE_TEMP_2,
CNPY_AIR_TEMP_120CM,CNPY_VAPOR_PRESS_120CM,CNPY_SURF_PRESS_170CM,LEAF_WET_160CM,
LEAF_WET_140CM,RAINFALL,CRTFCN_CODE,REVISION_DATE
'SSA-YJP-FLXTR','9TF04-FLX01',01-JUN-94,0,9999.0,-16.5,-999.0,-15.8,-46.0,-999.0,
-999.0,-999.0,-999.0,1.62,2.99,2.3,85.0,303.4,38.8,-999.0,-999.0,-999.0,-1.0,
763.0,12.95,20.91,-999.0,0.0,388.7,.687,.49,-999.0,.806,-999.0,999.0,-999.0,
-999.0,,,,,,,,0.0,'CPI',27-APR-99
```

8. Data Organization

8.1 Data Granularity

The smallest unit of data tracked by the BOREAS Information System (BORIS) was data collected at a given site on a given date.

8.2 Data Format

The Compact Disk-Read-Only Memory (CD-ROM) files contain American Standard Code for Information Interchange (ASCII) numerical and character fields of varying length separated by commas. The character fields are enclosed with single apostrophe marks. There are no spaces between the fields.

Each data file on the CD-ROM has four header lines of Hyper-Text Markup Language (HTML) code at the top. When viewed with a Web browser, this code displays header information (data set title, location, date, acknowledgments, etc.) and a series of HTML links to associated data files and related data sets. Line 5 of each data file is a list of the column names, and line 6 and following lines contain the actual data.

9. Data Manipulations

9.1 Formulae

9.1.1 Derivation Techniques and Algorithms

Vapor pressure was calculated as product of saturated vapor pressure at air temperature and relative humidity. Saturated vapor pressure was calculated using the Lowe (1977) equation.

Tree bole temperatures were scanned every 5 s during the last minute of each half-hour, and averages of the 13 readings were recorded. Thermocouples were inserted into the boles of two trees on the north, east, south, and west sides, to approximately one half the radius of the trunk, at four heights. In the reported data set the 16 temperatures from each tree were averaged together for each half-hour, and the mean temperature was reported.

9.2 Data Processing Sequence

9.2.1 Processing Steps

BORIS staff processed these data by:

- Reviewing the initial data files and loading them online for BOREAS team access.
- Designing relational data base tables to inventory and store the data.
- Loading the data into the relational data base tables.
- Working with the team to document the data set.
- Extracting the data into logical files.

9.2.2 Processing Changes

None.

9.3 Calculations

9.3.1 Special Corrections/Adjustments

Air pressure was recorded to the nearest mb until day of year 215 at 2000 GMT, and to the nearest hundredth of a mb thereafter.

9.3.2 Calculated Variables

See Section 9.1.1.

9.4 Graphs and Plots

None.

10. Errors

10.1 Sources of Error

None given.

10.2 Quality Assessment

10.2.1 Data Validation by Source

None given.

10.2.2 Confidence Level/Accuracy Judgment

None given.

10.2.3 Measurement Error for Parameters

None given.

10.2.4 Additional Quality Assessments

None given.

10.2.5 Data Verification by Data Center

Data were examined to check for spikes, values that are four standard deviations from the mean, long periods of constant values, and missing data.

11. Notes

11.1 Limitations of the Data

These data were collected during the growing season; thus, there was little data collected under cold conditions.

11.2 Known Problems with the Data

The tipping bucket rain gauge was deployed in clearing about 10 m in diameter. The 45° cone above the rain gauge may have been slightly encroached upon by treetops.

There is a gap in the CO_2 data following a lightning strike and a malfunction of the CO_2 sensor 16-Jun to 20-Jun and 10-Jul to 19-Jul-1994. CO_2 profile instruments were not operational until IFC-2. The forest floor sensible and latent heat flux record had numerous lapses due to equipment problems.

11.3 Usage Guidance

None given.

11.4 Other Relevant Information

None.

12. Application of the Data Set

These data are useful for the study of water, energy, and carbon exchange in a young jack pine forest.

13. Future Modifications and Plans

None.

14. Software

14.1 Software Description

None given.

14.2 Software Access

None given.

15. Data Access

The SSA-YJP tower flux, meteorological, and canopy condition data are available from the Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

15.1 Contact Information

For BOREAS data and documentation please contact:

ORNL DAAC User Services
Oak Ridge National Laboratory
P.O. Box 2008 MS-6407
Oak Ridge, TN 37831-6407
Phone: (423) 241-3952
Fax: (423) 574-4665
E-mail: ornldaac@ornl.gov or ornl@eos.nasa.gov

15.2 Data Center Identification

Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC) for Biogeochemical Dynamics http://www-eosdis.ornl.gov/.

15.3 Procedures for Obtaining Data

Users may obtain data directly through the ORNL DAAC online search and order system [http://www-eosdis.ornl.gov/] and the anonymous FTP site [ftp://www-eosdis.ornl.gov/data/] or by contacting User Services by electronic mail, telephone, fax, letter, or personal visit using the contact information in Section 15.1.

15.4 Data Center Status/Plans

The ORNL DAAC is the primary source for BOREAS field measurement, image, GIS, and hardcopy data products. The BOREAS CD-ROM and data referenced or listed in inventories on the CD-ROM are available from the ORNL DAAC.

16. Output Products and Availability

16.1 Tape Products

None.

16.2 Film Products

None.

16.3 Other Products

These data are available on the BOREAS CD-ROM series.

17. References

17.1 Platform/Sensor/Instrument/Data Processing Documentation

None.

17.2 Journal Articles and Study Reports

Lowe, P.R. 1977. An approximating polynomial for the computation of saturation vapor pressure. Journal of Applied Meteorology, 16(1): 100-103.

Newcomer, J., D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers, eds. 2000. Collected Data of The Boreal Ecosystem-Atmosphere Study. NASA. CD-ROM.

Sellers, P. and F. Hall. 1994. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1994-3.0, NASA BOREAS Report (EXPLAN 94).

Sellers, P. and F. Hall. 1996. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1996-2.0, NASA BOREAS Report (EXPLAN 96).

Sellers, P., F. Hall, and K.F. Huemmrich. 1996. Boreal Ecosystem-Atmosphere Study: 1994 Operations. NASA BOREAS Report (OPS DOC 94).

Sellers, P., F. Hall, and K.F. Huemmrich. 1997. Boreal Ecosystem-Atmosphere Study: 1996 Operations. NASA BOREAS Report (OPS DOC 96).

Sellers, P., F. Hall, H. Margolis, B. Kelly, D. Baldocchi, G. den Hartog, J. Cihlar, M.G. Ryan, B. Goodison, P. Crill, K.J. Ranson, D. Lettenmaier, and D.E. Wickland. 1995. The boreal ecosystem-atmosphere study (BOREAS): an overview and early results from the 1994 field year. Bulletin of the American Meteorological Society. 76(9):1549-1577.

Sellers, P.J., F.G. Hall, R.D. Kelly, A. Black, D. Baldocchi, J. Berry, M. Ryan, K.J. Ranson, P.M. Crill, D.P. Lettenmaier, H. Margolis, J. Cihlar, J. Newcomer, D. Fitzjarrald, P.G. Jarvis, S.T. Gower, D. Halliwell, D. Williams, B. Goodison, D.E. Wickland, and F.E. Guertin. 1997. BOREAS in 1997: Experiment Overview, Scientific Results and Future Directions. Journal of Geophysical Research 102(D24): 28,731-28,770.

17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

None.

19. List of Acronyms

ASCII	- American Standard Code for Information Interchange
ATD	- Atmospheric Technology Division
ATI	- Applied Technologies, Inc.
BOREAS	- BOReal Ecosystem-Atmosphere Study
BORIS	- BOREAS Information System
CD-ROM	- Compact Disk-Read-Only Memory
DAAC	- Distributed Active Archive Center
EOS	- Earth Observing System
EOSDIS	- EOS Data and Information System
GIS	- Geographic Information System
GMT	- Greenwich Mean Time
GSFC	- Goddard Space Flight Center
HTML	- Hyper-text Markup Language
IFC	- Intensive Field Campaign
NAD83	- North American Datum of 1983
NASA	- National Aeronautics and Space Administration
NCAR	- National Center for Atmospheric Research
NEP	- Net Ecosystem Productivity
NSA	- Northern Study Area
ORNL	- Oak Ridge National Laboratory
PANP	- Prince Albert National Park
PAR	- Photosynthetically Active Radiation
SSA	- Southern Study Area
TF	- Tower Flux
URL	- Uniform Resource Locator
USGS	- United States Geological Survey
YJP	- Young Jack Pine

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Anderson, D., R. Striegl, and K. Wickland, "Exchange of Trace Gases, Water, and Energy in Disturbed and Undisturbed Boreal Forests." In Collected Data of The Boreal Ecosystem-Atmosphere Study. Eds. J. Newcomer, D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers. CD-ROM. NASA, 2000.

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13. ABSTRACT *(Maximum 200 words)*

The BOREAS TF-4 team collected energy, carbon dioxide, and water vapor flux data at the BOREAS SSA-YJP site during the growing season of 1994. In addition, meteorological data were collected both above and within the canopy. The data are available in tabular ASCII files.

14. SUBJECT TERMS
BOREAS, tower flux, meteorological data, canopy condition data.

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